International Space Station Program

D684-13036-01

EVA Analysis Report

AMS to S3 Contingency CAS Release

Type 4 Document

9/26/2008

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REVISION AND HISTORY PAGE

Rev.	Description	SSCN	Analyst	Pub. Date
-	Initial Release	010446	Mariana Monsalve	10-13-08

ERU /s/ Mary C. Nooney 10-13-08

PREFACE

The D684-13036-01 is an internal Prime Contractor document and is not required for delivery to NASA. This document is controlled by the EVA&CSI Team and any changes to this document must be approved by the EVA&CSI Team.

/s/ Terri B. Puckett
Manager

10-3-08
Date

INTERNATIONAL SPACE STATION PROGRAM
EVA Analysis Report
AMS to S3 Contingency CAS Release
9/26/2008

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LIST OF CHANGES

All changes to paragraphs, tables, and figures in this document are shown below:

REVISION	DATE	CHANGES

EVA Analysis Report

Title: AMS to S3 Contingency CAS Release **EVAP:** 0347

Type: Contingency **Flight:** **Element:** S3

Description

The Alpha Magnetic Spectrometer (AMS) is a state-of-the-art particle physics detector containing a large, cryogenic superfluid helium superconducting magnet that will use the unique environment of space to advance knowledge of the universe and potentially lead to a clearer understanding of the universe's origin. Specifically, the science objectives of the AMS are to search for cosmic sources of antimatter (i.e., anti-helium or heavier elements), dark matter, and dark energy.

The AMS is currently not scheduled to be installed during a flight. However, it needs to be assessed on the Strarboard Truss Segment 3 (S3) Zenith Inboard Payload Attach System (PAS) site. The PAS provides structural, power, and data interfaces that enable the AMS to attach to its designated S3 site located on the International Space Station (ISS).

This assessment will be completed in order to support the closure of exception 57213-0004.

This analysis determines whether the Extravehicular Activity (EVA) requirements are met for two sets of tasks involving the AMS on S3. The first task analyzed is the opening of S3 PAS Capture Latch Assembly (CLA). The second task analyzed is actuating the AMS Passive Payload Attach System (PPAS).

The positions in this analysis are Worksite Interface (WIF) and free-float based.

Generic Notes

Number	Description
1	All requirements verified, except the Remote Manipulator System (RMS) outfitting requirement, are detailed in the Extravehicular Activity (EVA) Analysis Report (EAR) Companion, A3-J083-DEA-M-9601527-Rev D, dated 16 January 1997. The EAR companion lists rationale for assigning requirement compliance, non-compliance, or non-applicability for a given task.
2	Verification of crewmember view of worksite is done by graphical analysis. If there is no interference with lines drawn from the eye points of 50th percentile American female, 50th percentile American male and 95th percentile American male and the worksite and those lines fall within the crewmember's field of view (see EAR Companion), field of view requirements are deemed verified.
3	For Shuttle Remote Manipulator System (SRMS) and Space Station Remote Manipulator System (SSRMS) based tasks, ingress/egress aids are not required to be provided on the structure due to the availability of the Portable Foot Restraint (PFR) Workstation Stanchion (WSS) on the Articulating Portable Foot Restraint (APFR).
4	Unigraphics (UG) EAR has been approved by Boeing Prime as a valid method for verification of the twelve Prime Item Development (PID) requirements listed in the EAR Companion (see Design Analysis Cycle 2, TDS 3.1.14-3). The RMS outfitting requirement was not included in this approval, but is included in this report for System Level verification. Areas/components not suitable for verification via current UG analysis are: dexterity/tactility, mass handling, forces and torque in multiple axes for hardware with a volume greater than 5 cubic feet and/or a mass greater than 50 lb., alignment tolerances, use of nonstandard controls and indicators, mental and physical fatigue levels, operational functionality, timeline determination, and manipulation of flexible hardware (i.e. cables, umbilicals, tethers).
5	Crew and Equipment Translation Assembly (CETA) cart locations are shown based on the Y0 position (in centimeters) of the port edge of the CETA cart per Space Station Program (SSP) 30256. Nadir and Zenith swing arm locations are indicated by a position number.
6	For tasks based on the RMS, refer to the Manipulator Analysis - Graphic, Interactive, Kinematic (MAGIK) report listed in the "References" section for the RMS positions.
7	This analysis assumes all mechanisms are compliant with EVA force requirements.
8	This report is used to verify EVA requirements. Actual operational procedures may vary due to crew preference, operational constraints, and the use of non-baselined EVA hardware and techniques.
9	This analysis was conducted per process HOU-EGD-066, EVA&CSI Graphical Analysis Process. The analysis process is documented in the Boeing Houston Procedure Documentation System (PDS).
10	Any illustration shown in the "Procedural Steps" section does not constitute as requirement verification. These illustrations represent the UG models, which were used for the requirement verification in this report.
11	The illustrations taken for this analysis were created from the UG part file that corresponds to the document number of this report. Refer to HOU-EGD-066 for the location of the file.

12 Positions that are identical to previously analyzed positions (meaning it has the same platform and APFR settings) are not re-evaluated. Therefore, the compliance information may not be present and the reader is directed to the analysis of the previous position. This is the typical situation for remove and replace (R&R) operations in which one step removes an item and the replacement step is the reverse. This keeps the compliance matrix concise without redundant positions.

13 For a free float task, the Dedicated Worksite Outfitting, the Work Envelope, APFR Ingress, and Stability Aid requirements do not apply because they are all based on a foot restraint. However, the UG graphical envelopes for the Work Envelope and Stability Aid are used to verify the Free Float Outfitting requirement. The APFR Installation requirement only applies when showing the installation of the APFR from the Free Float position.

14 All EVA Tools listed in the "Tools Used" section of the steps are configured prior to the tasks described in this analysis.

15 The Three Dimensional (3D) graphical models used to verify the EVA requirements in this analysis are results of the efforts made by the EVA & Crew System Integration (CSI) Team to obtain accurate models from the International Space Station (ISS) 3D Computer Aided Design (CAD) Team. These models reflect the as-designed configuration. If the necessary models are not available from the ISS 3D CAD Team, then they are obtained from the hardware designers, released drawings or other documentation from the hardware designers.

16 The Dedicated Worksite Outfitting requirement will be marked non-compliant if the APFR Installation, APFR Ingress and/or Stability Aids requirement are marked non-compliant. When the APFR Installation, APFR Ingress and/or Stability Aids requirements are granted an exception, then the Dedicated Worksite Outfitting requirement will be marked compliant with exception.

17 The EVA Analysis and Integration Team (AIT) prefers that EVA Analysis Reports do not use the Worksite Interface (WIF) Extender as a platform unless National Aeronautics and Space Administration (NASA)-EVA Office plans to use the WIF Extender on-orbit and NASA-EVA Tools has concurred. This preference was explained during the EVA AIT on June 13, 2006.

Assumptions

Number	Description
1	All 4 S3 PASs are deployed.
2	ExPRESS Logistics Carrier (ELC) is attached to S3 Zenith Outboard (Starboard) PAS.
3	AMS is attached to S3 Zenith Inboard (Port) PAS.
4	S1 Camera Port (CP) 2 is empty with Floating Potential Measurement Unit (FPMU) removed.

Notes

Number	Step	Note
1		For this analysis, the ISS Coordinate System (CSYS) is used.
2		Step Summary: Step 1 applies to opening the S3 PAS CLA. Steps 2-3 apply to releasing the AMS PPAS Load Release Bolts and Capture Bar Handle. (Steps 2 and 3 pertain to the contingency removal of AMS from S3 by actuation of the PAS and PPAS are only needed if the removal operations in Step 1 fail.)
3		The following items do not have flight labels. Labels were assigned to each item for reference only and are shown in the Hardware Familiarization section of this report: 1) AMS 2) AMS PPAS 3) PAS
4		Structures and Mechanisms and Thermal concurrence for the statement that the S3 PAS can be used as a stabilization aid was provided in MDC 97H0479 Sections 1.0 and 8.4 and MDC 99H0286 Section 5.1.1. EVA Analysis Report MDC 96H0576 also explains concurrence in Note 7-6.

Related Drawings

Number	Rev.	Title
1F70142	K	MECHANISM ASSEMBLY, UMBILICAL, ACTIVE, ELECTRICAL - UCCAS
1F70157	F	PAYLOAD ATTACH SYSTEM ASSY, SEGMENT S3
1F70162	F	UMBILICAL MECHANISM, PASSIVE HALF-ULC
1F91504	D	ELECTRICAL INSTL, VIDEO CAMERA - TVCIC
SEG39135720		ALPHA MAGNETIC SPECTROMETER

SEG39135812 - PAS ASSEMBLY, AMS PAYLOAD ASSEMBLY

References

Reference Number	Rev	Title
57213-0004	-	AMS (Alpha Magnetic Spectrometer) On-orbit Operations Envelope Exceedance
A3-J083-DEA-M-9601527	D	EAR Companion Rev D (EVA Worksite Analysis Report Companion)
BOE-00006_SSP57003	-	S3 Exceptions to the Working Volume Requirements in Support of the AMS Payload
BOE-00007_SSP57003	-	S3 Exceptions to the EVA Crewmember Field of View Requirement in Support of the AMS Payload
CB-02-043	-	Temporary Equipment Restraint Aid (TERA) NBL Development Test
CCR_02-043-2	D	AMS Capture Bar Release Piggyback to TERA NBL Test
D684-12326-01	B	EVA Analysis Report: ESP-3 Install to P3 and CAS Release
D684-12654-01	-	EVA Analysis Report: EVA Aids on S3
EVA AIT Minutes 9-4-2008	-	Minutes for September 4, 2008 EVA AIT
HOU-EGD-066	-	EVA&CSI Graphical Analysis Process
MAGIK_AI_2279	A	AMS Installation
MDC 97H0479	C	Comman Attach System (CAS) Structural Integrity Report
MDC 99H0286	-	International Space Station P3 and S3 Segment PTCS Verification Analysis Report
MDC96H0576	E	Layout, EVA Analysis S3/P3, Faces 3,4,5 Miscellaneous Maintenance
SP-M-229	T	Addendum Specification Integrated Truss Element S3
SSP57213	-	Alpha Magnetic Spectrometer-02 (AMS-02) Hardware Interface Control Document

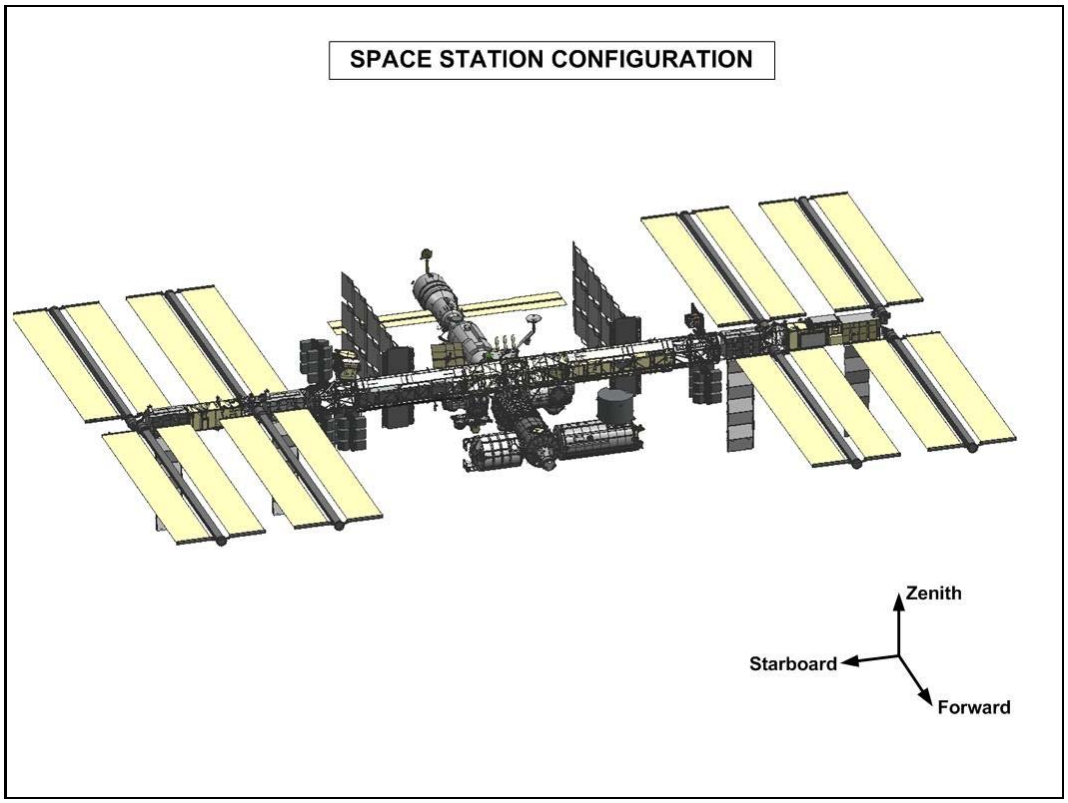
Initial and Final Conditions

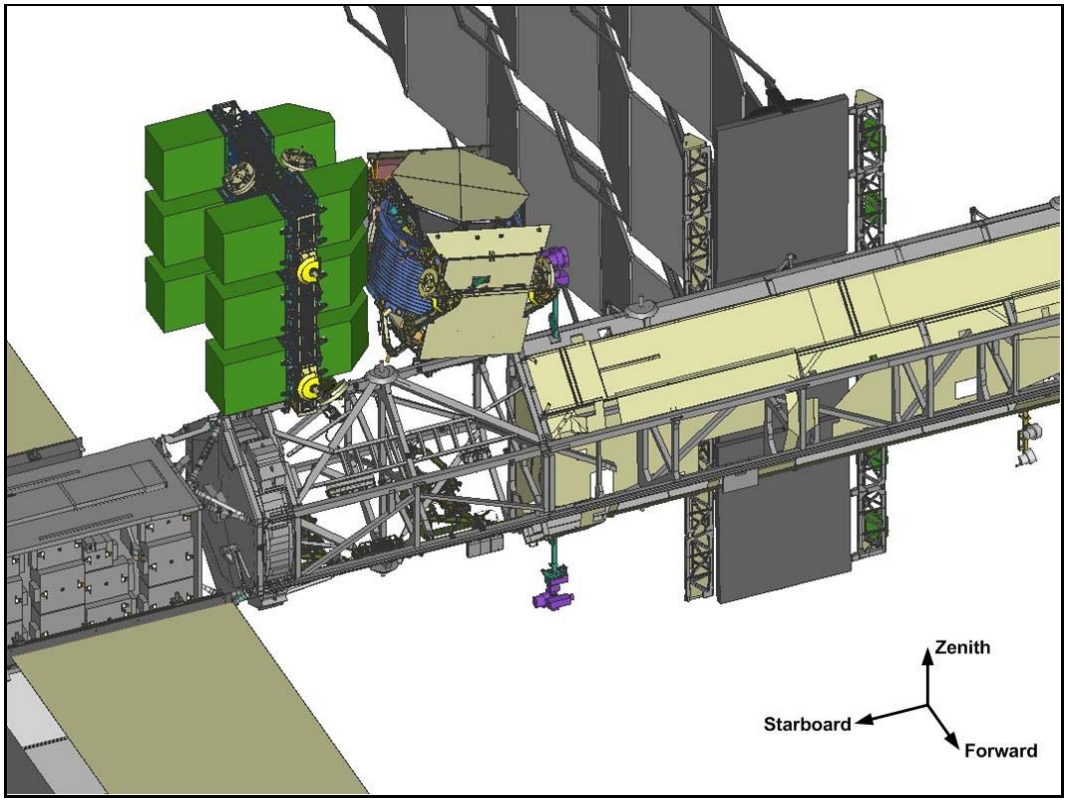
Number	Item	Initial Condition	Final Condition
1	AMS	AMS installed onto S3 Zenith Port (Inboard) PAS.	AMS removed from S3 Zenith Port (Inboard) PAS.

Operational Constraints

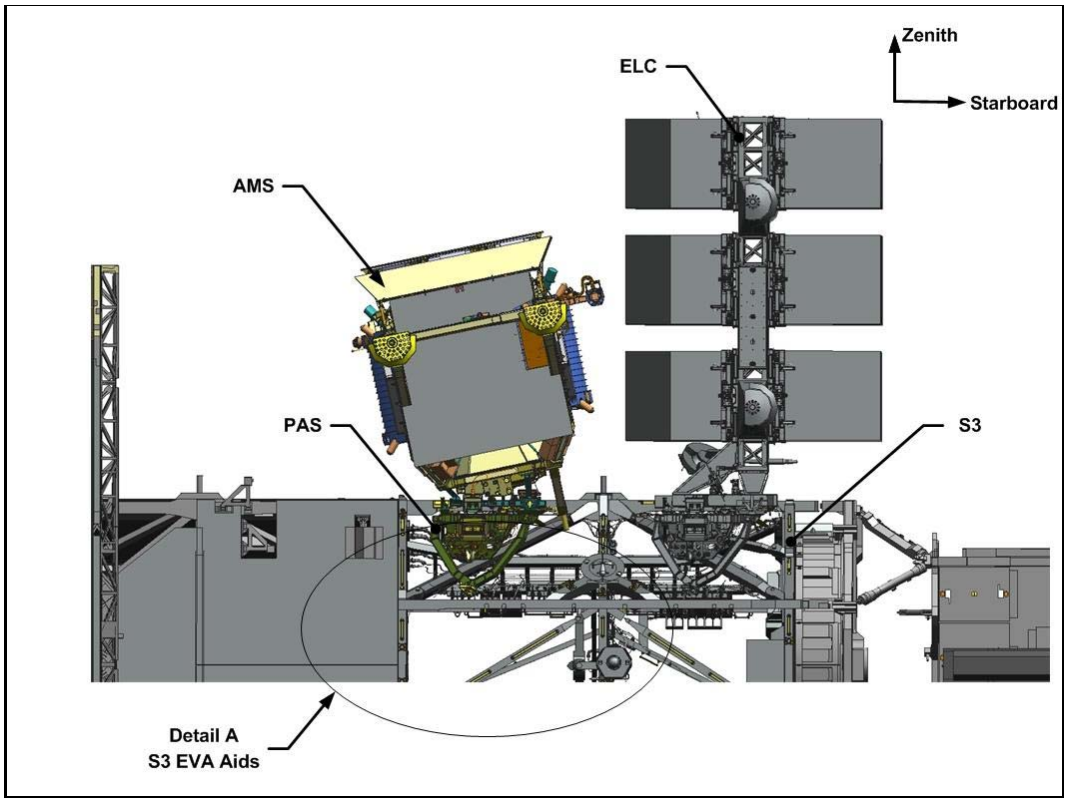
Number	Title	Description
1	SSRMS	SSRMS must be grappled to AMS before attempting any EVA tasks described in this analysis.
2	UMA	The Umbilical Mechanism Assembly (UMA) is disconnected before PAS contingency release.

International Space Station Configuration

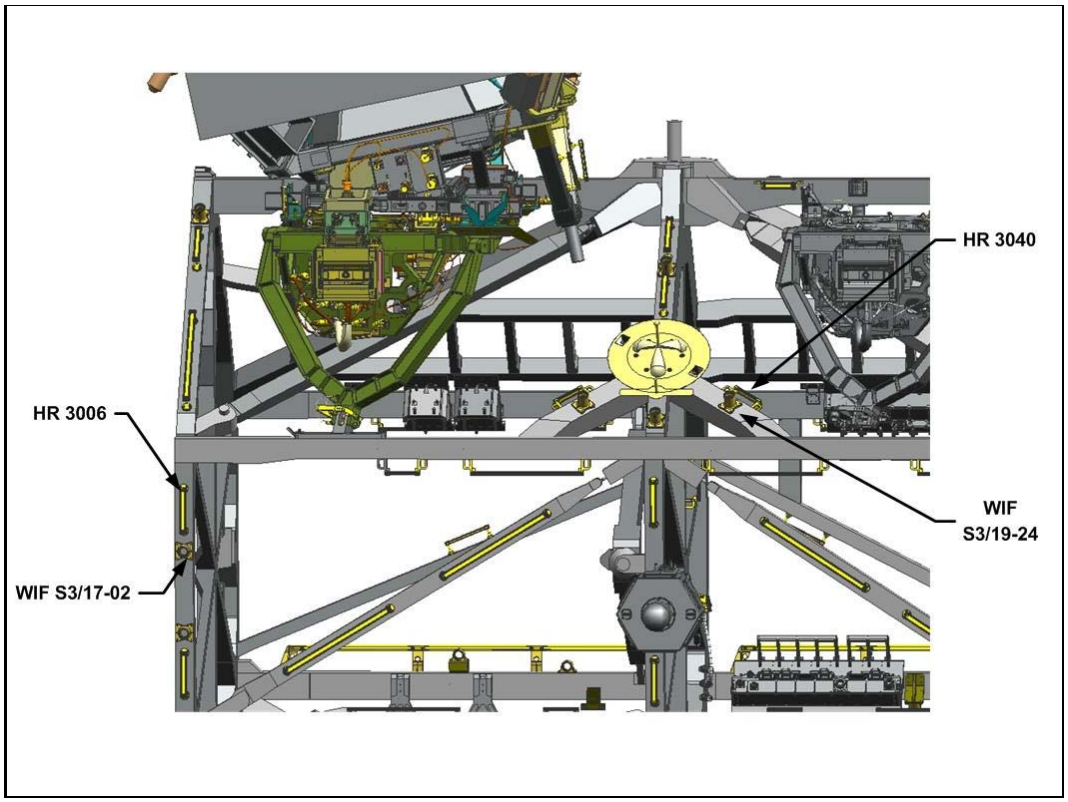




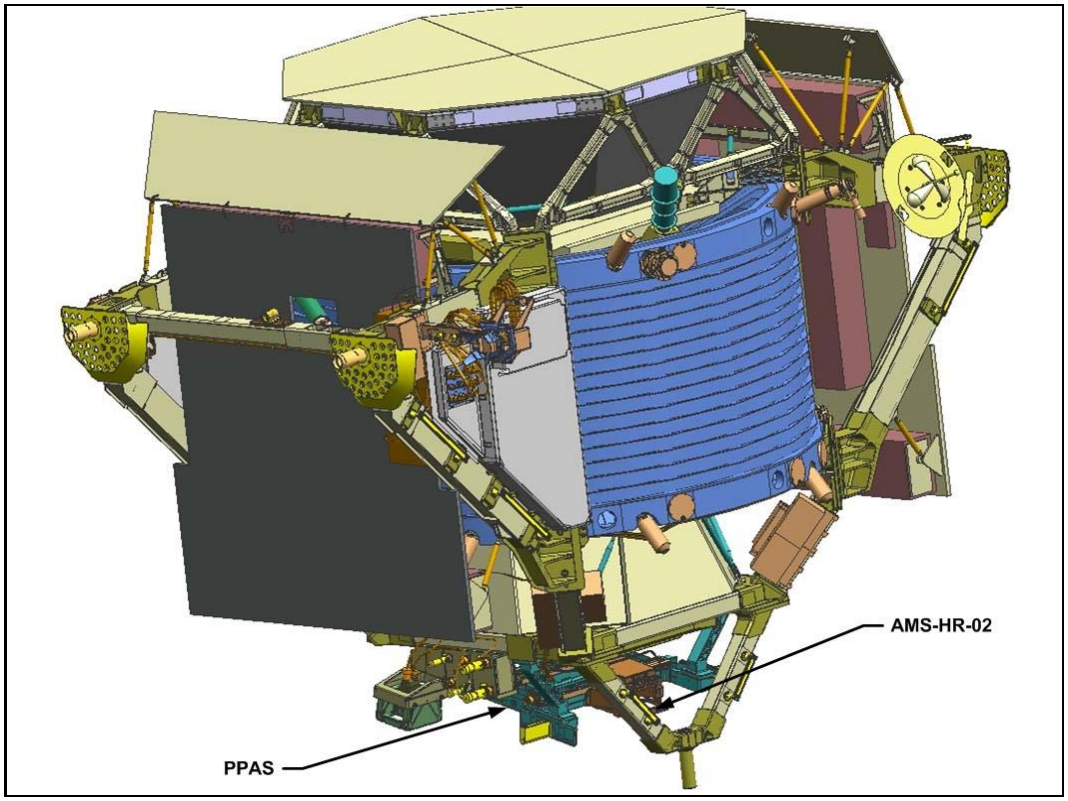
Hardware Familiarization



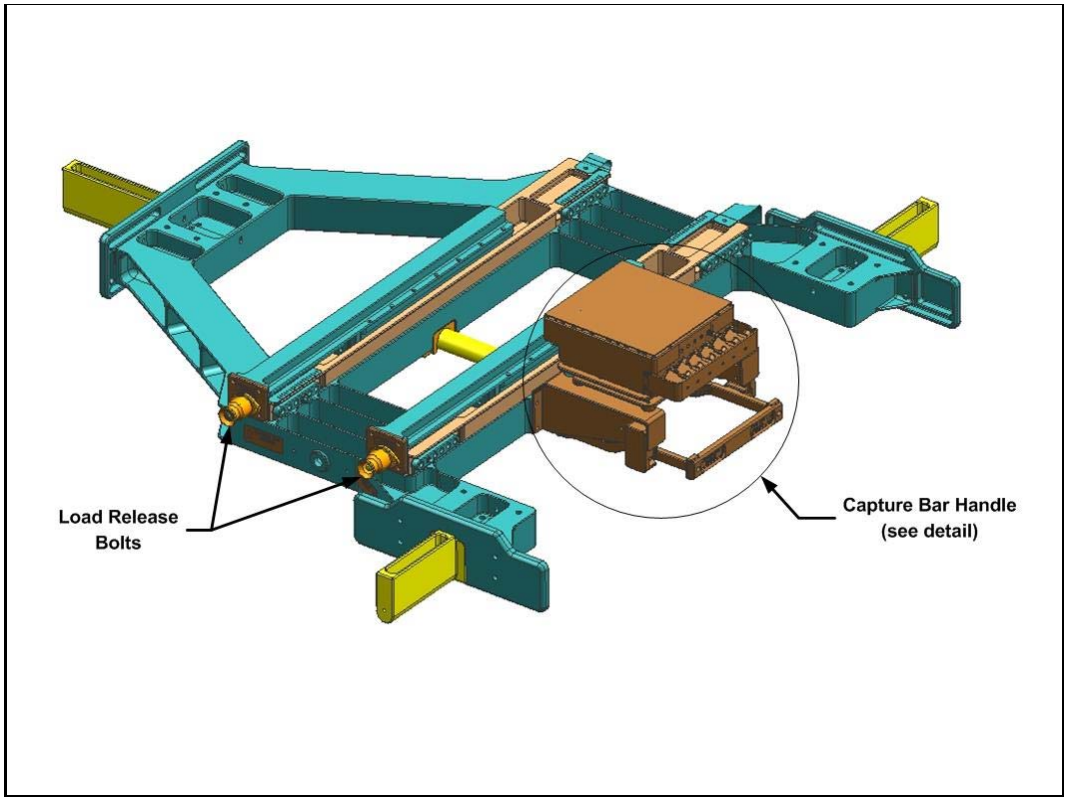
Worksite Overview



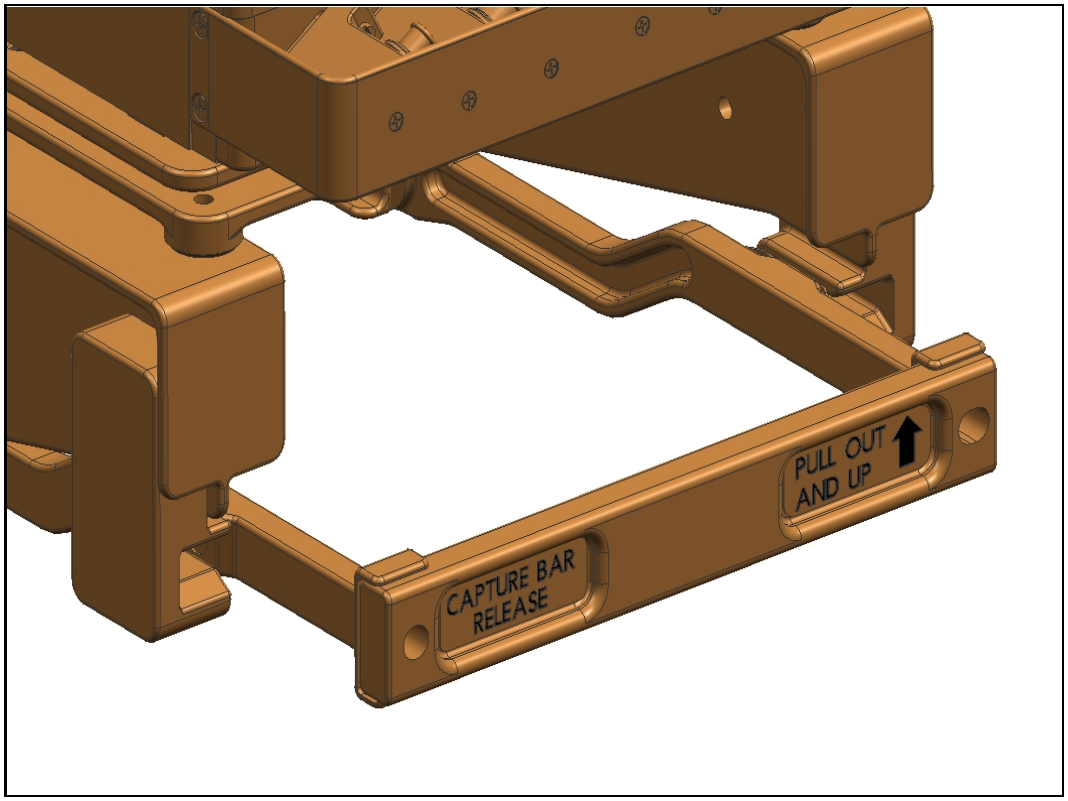
Detail A. S3 EVA Aids



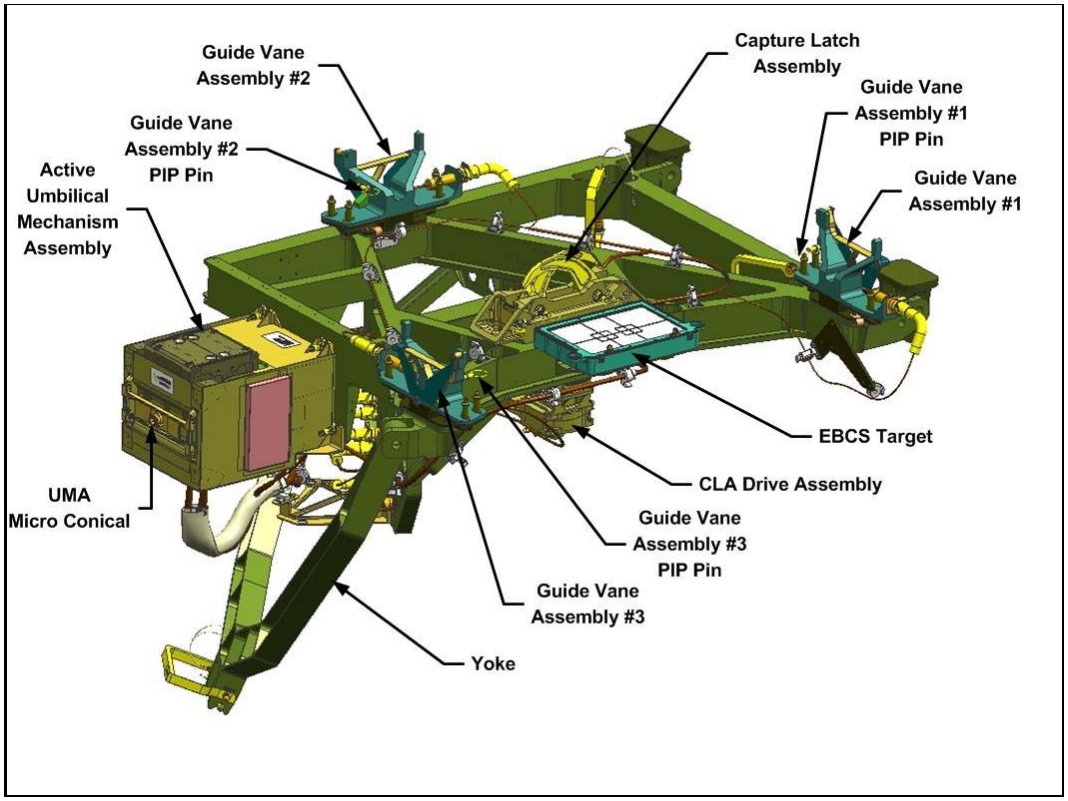
AMS Interfaces



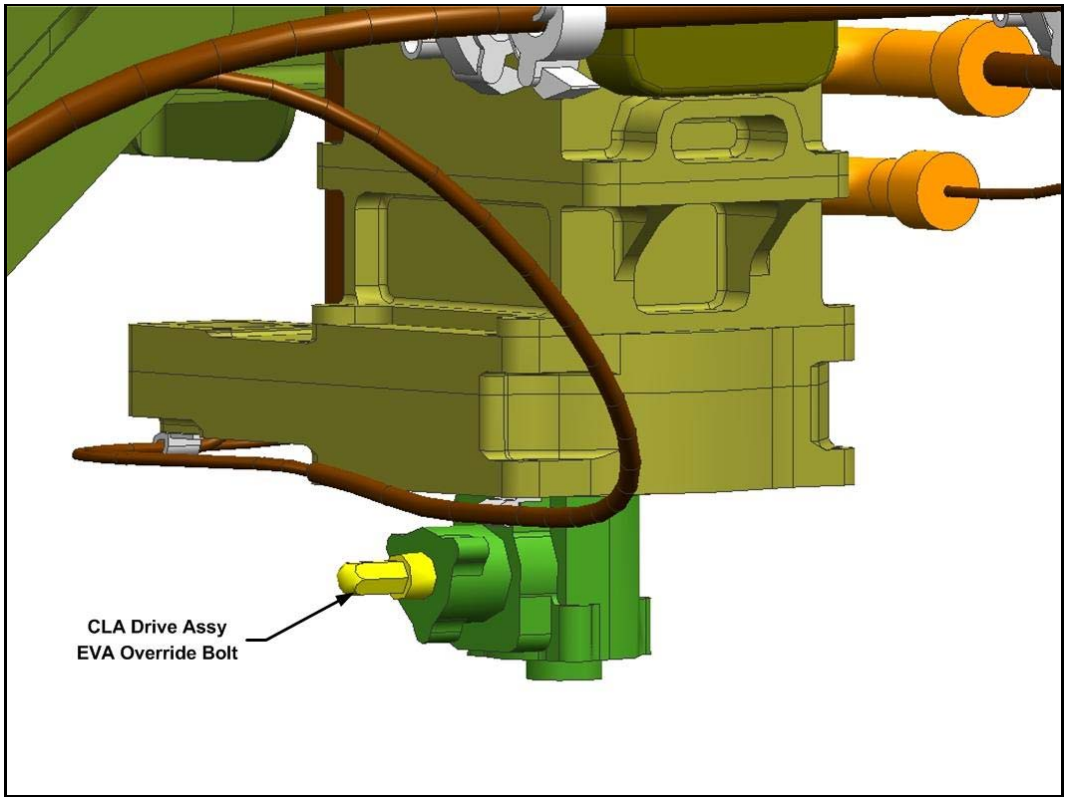
AMS PPAS Interfaces



PPAS Capture Bar Handle Detail



PAS Detailed



CLA EVA Bolt

Procedural Steps

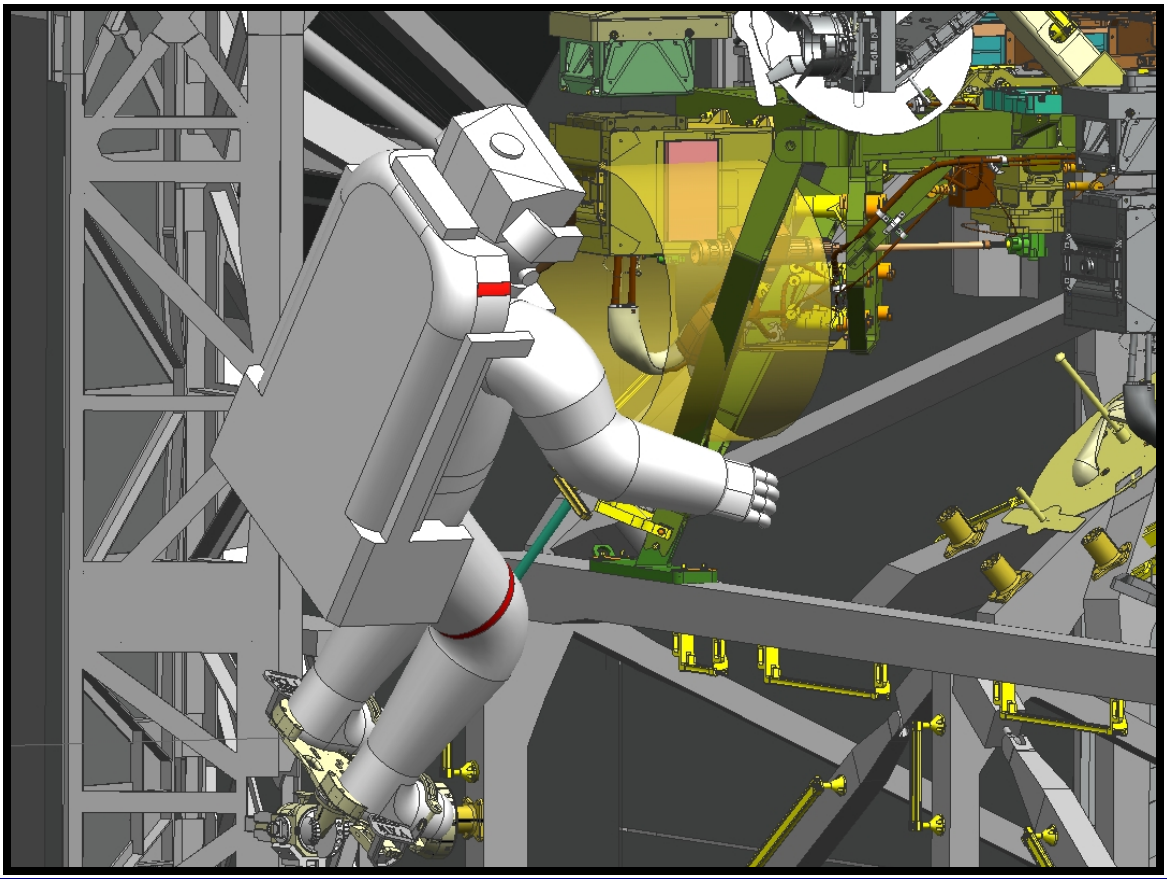
Step 1

EV1 Open S3 PAS CLA

Platform: WIF

Open the S3 PAS CLA by disengaging the EVA Override Bolt. Turn the EVA Override Bolt with Pistol Grip Tool (PGT) and 7/16" x 18" Socket Ext (Wobble).

See Note 4.

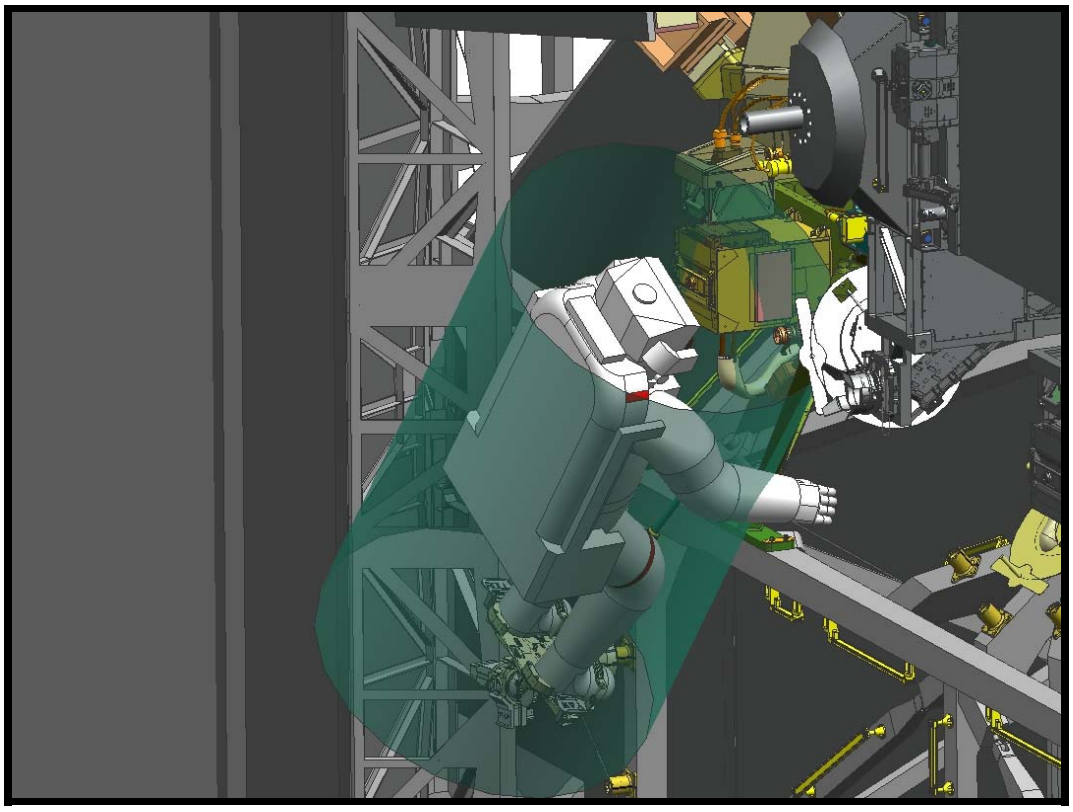


Step Requirement Assessment

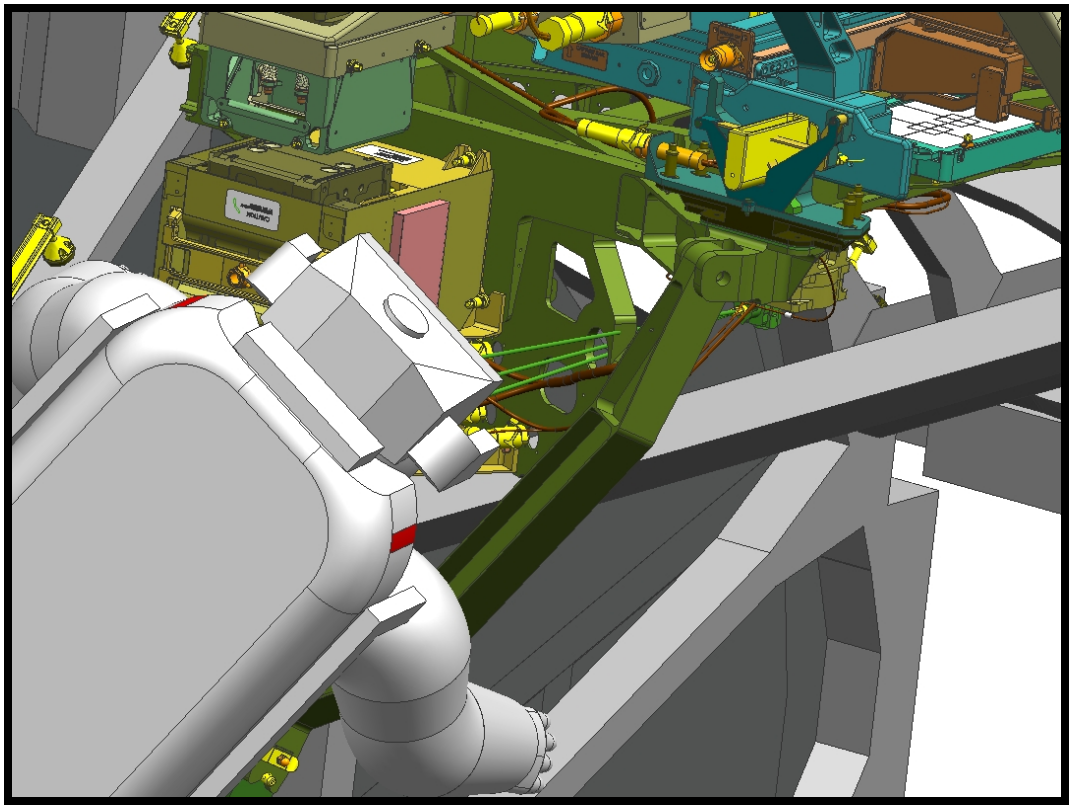
Worksite Outfitting	Free-Float Outfitting	RMS Outfitting	Work Envelope	Field of View	48" Work Volume	Mobility Aids	APFR Installation	APFR Ingress	Stability Aids	Glove Clearance	Handrail Envelope	WIF Envelope
C	n/a	n/a	C	Ce	Ce	C	C	C	C	C	Ce	C

Handrail/Handhold	Usage	Tool	Part Number	Quantity
APFR Ingress Aid	APFR Ingress	7/16" x 18" Socket Ext (Wobble)	SEG33106933-301	1
3006	APFR Installation	APFR Assy	SEG33106857-301	1
S3 PAS	Stabilization	APFR Ingress Aid	SED39127050-301	1
		Pistol Grip Tool (PGT)	GE1557000	1

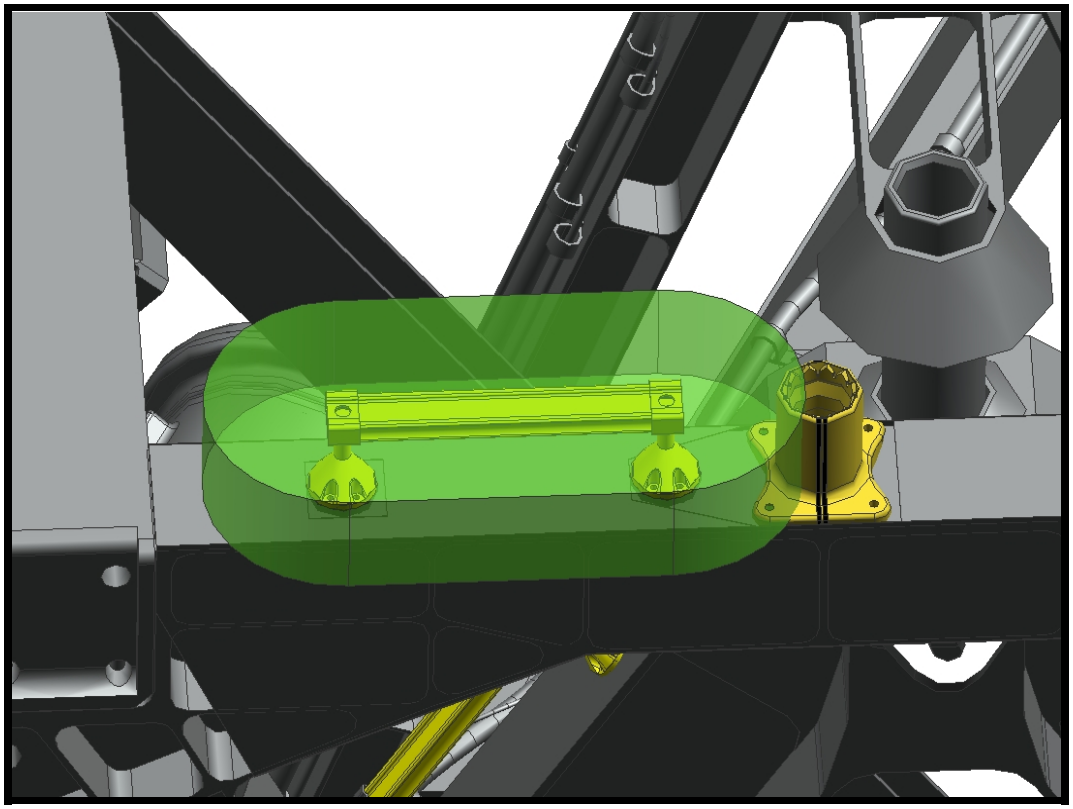
APFR		WSS	WIF Extender	CETA Cart	UG Data
WIF:	S3/17-02	***Yaw:***	***Clock:***	***Loc:***	***SSRMS#:***
Clock:	12:00 (0/360)	***Clock:***	***Pitch:***	***Arm Set:***	***MT#:***
Pitch:	QQ (-9)	***Pitch:***	***Length:***	***WIF Yaw:***	***MBS#:***
Roll:	J (-54)	***Toolhead:***		***WIF Pitch:***	***CETA#:***
Yaw:	12:00 (0/360)				***EV#:*** 1



48 inch Work Volume Non-Compliant: Envelope is violated by S3 UMA. See Remarks section for the exception to this violation.



Field of View Non-Compliant: View is obstructed by S3 PAS. See Remarks section for the exception to this violation.



Handrail 3006 Non-Compliant: Handrail Envelope is violated by WIF S3/17-02. See Remarks section for the exception to this violation.

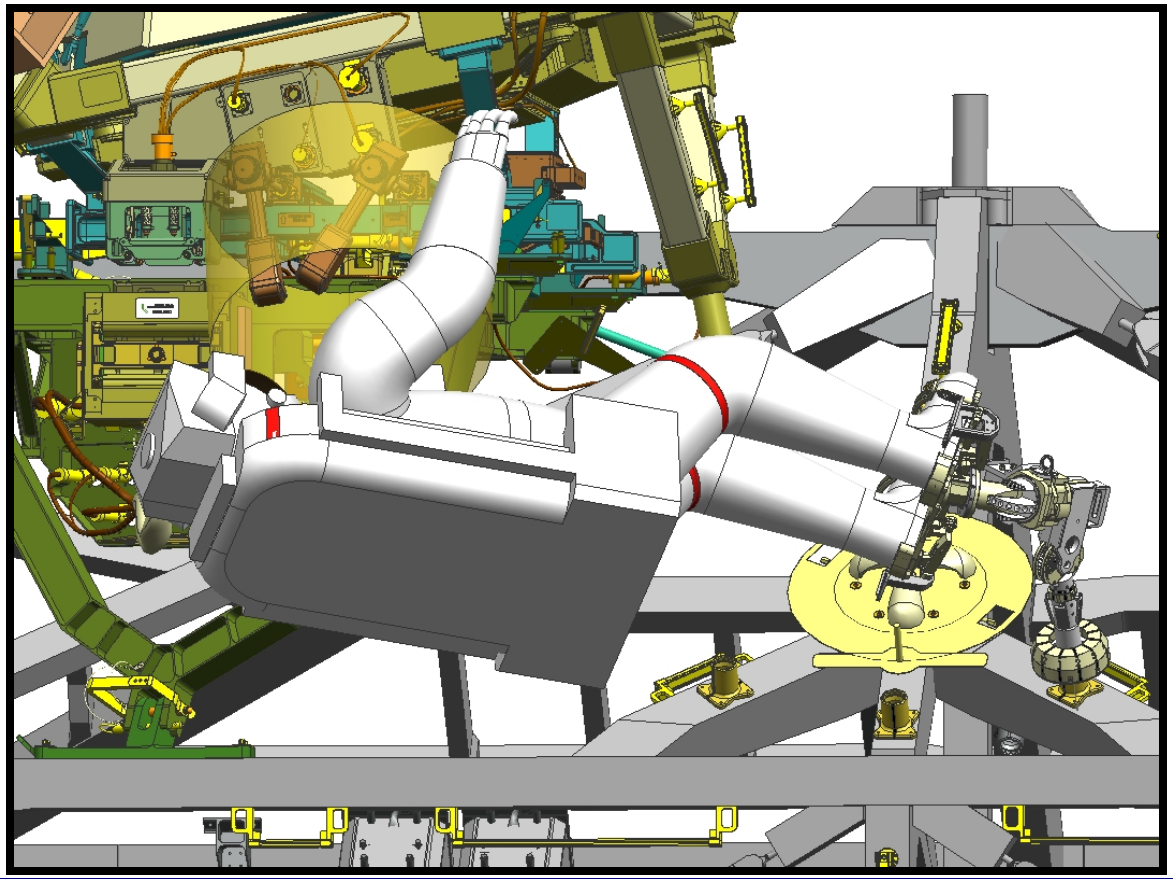
Step 2

EV1 Actuate AMS PPAS Load Release Bolts

Using PGT with 7/16" x 18" socket (wobble), unscrew Load Release Bolts.
Each Load Release Bolt requires ~80 turns. Alternate between the two bolts turning each ~10 turns each time (but no more than 20 turns) until the bar is completely unloaded.

Platform: WIF

Contingency Step



Step Requirement Assessment

Worksite Outfitting	Free-Float Outfitting	RMS Outfitting	Work Envelope	Field of View	48" Work Volume	Mobility Aids	APFR Installation	APFR Ingress	Stability Aids	Glove Clearance	Handrail Envelope	WIF Envelope
C	n/a	n/a	C	C	C	C	C	C	C	C	C	C

Handrail/Handhold	Usage	Tool	Part Number	Quantity
APFR Ingress Aid	APFR Ingress	7/16" x 18" Socket Ext (Wobble)	SEG33106933-301	1
3040	APFR Installation	APFR Assy	SEG33106857-301	1
S3 PAS	Stabilization	APFR Ingress Aid	SED39127050-301	1
		Pistol Grip Tool (PGT)	GE1557000	1

APFR		WSS	WIF Extender	CETA Cart	UG Data	
WIF:	S3/19-24	***Yaw:***	***Clock:***	***Loc:***	***SSRMS#:***	
Clock:	12:00 (0/360)	***Clock:***	***Pitch:***	***Arm Set:***	***MT#:***	
Pitch:	MM (+27)	***Pitch:***	***Length:***	***WIF Yaw:***	***MBS#:***	
Roll:	D (+36)	***Toolhead:***		***WIF Pitch:***	***CETA#:***	
Yaw:	4:00 (120)				***EV#:***	3

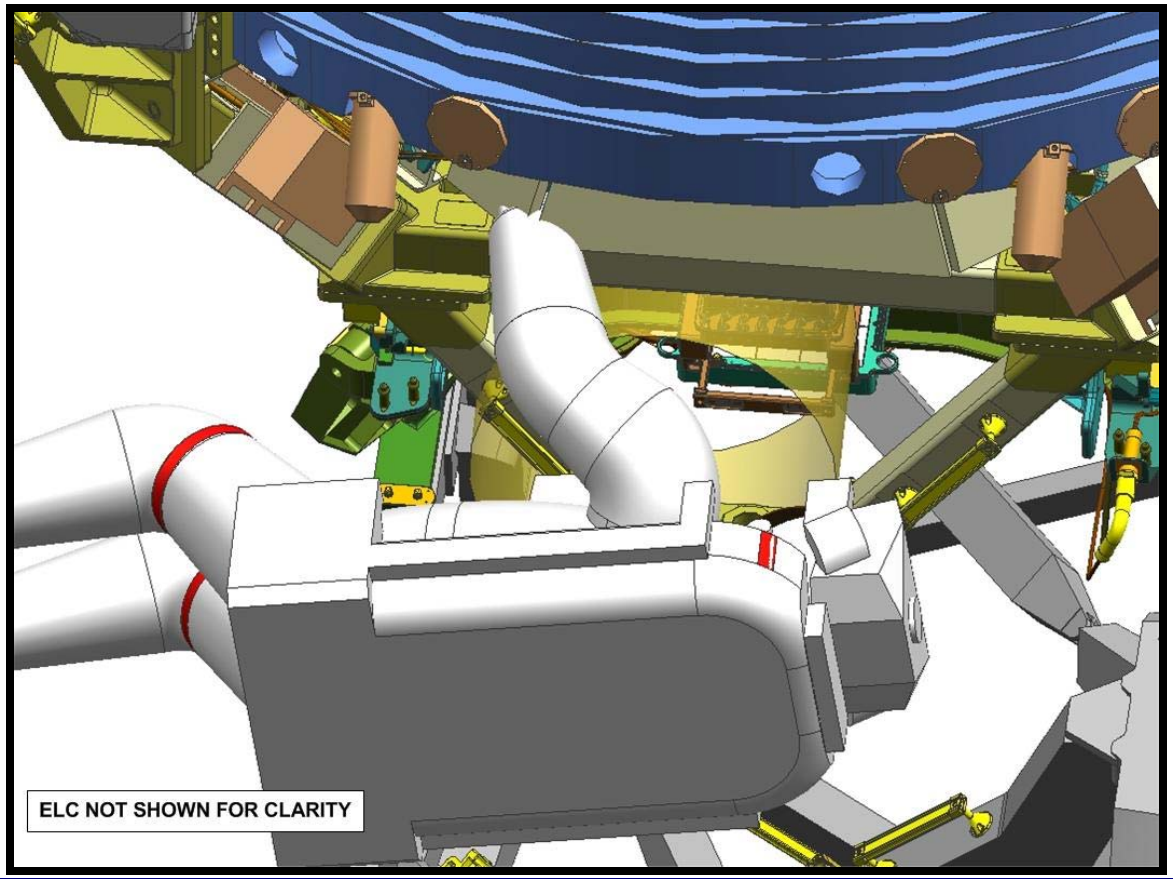
Step 3

EV1 Actuate AMS PPAS Capture Bar Handle

Actuate the AMS PPAS Capture Bar by pulling out and up on the Capture Bar Handle.

Platform: Free Float

Contingency Step

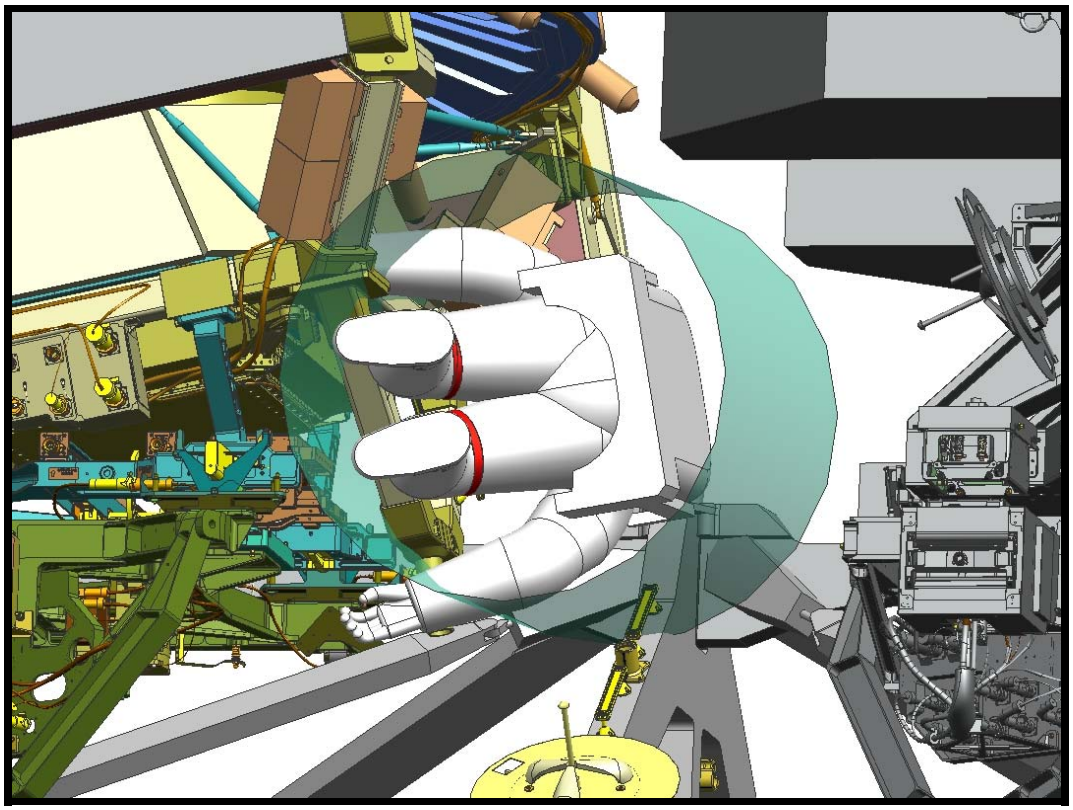


Step Requirement Assessment

Worksite Outfitting	Free-Float Outfitting	RMS Outfitting	Work Envelope	Field of View	48" Work Volume	Mobility Aids	APFR Installation	APFR Ingress	Stability Aids	Glove Clearance	Handrail Envelope	WIF Envelope
n/a	C	n/a	n/a	C	Ce	C	n/a	n/a	n/a	C	C	n/a

Handrail/Handhold	Usage	Tool	Part Number	Quantity
AMS-HR-02	Stabilization	None		

APFR	WSS	WIF Extender	CETA Cart	UG Data
WIF:	***Yaw:***	***Clock:***	***Loc:***	***SSRMS#:***
Clock:	***Clock:***	***Pitch:***	***Arm Set:***	***MT#:***
Pitch:	***Pitch:***	***Length:***	***WIF Yaw:***	***MBS#:***
Roll:	***Toolhead:***		***WIF Pitch:***	***CETA#:***
Yaw:				***EV#:*** 2



48 inch Work Volume Non-Compliant: Envelope is violated by S3 structure. See Remarks section for the exception to this violation.

Applicable Requirements

SSP30256H (Reference Only)	Extravehicular Activity (EVA) Standard Interface Control Document
SSP41162AY	Segment Specification for the United States On-Orbit
SSP50005E (Reference Only)	International Space Station Flight Crew Integration
SSP57003D	Attached Payload Hardware Interface Control Requirements Document

Requirement Paragraph Mapping

Document Number	Worksite Outfitting	Free-Float Outfitting	RMS Outfitting	Work Envelope	Field of View	48 Work Volume	Mobility Aids	APFR Installation	APFR Ingress	Stability Aids	Glove Clearance	Handrail Envelope	WIF Envelope
SSP30256H (Reference Only)	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	3.6.1.2.2	3.6.4.2.2
SSP41162AY	3.2.2.5bc, 4.3.2.2.5bc	3.2.2.5d, 4.3.2.2.5d	3.2.2.5g, 4.3.2.2.5g	3.3.7.7.1, 4.3.3.7.7.1	3.3.7.7.2, 4.3.3.7.7.2	3.3.7.7.3, 4.3.3.7.7.3	NF	3.2.2.5f, 4.3.2.2.5f	3.2.2.5f, 4.3.2.2.5f	3.2.2.5e, 4.3.2.2.5e	3.3.7.3b, 4.3.3.7.3b	NF	NF
SSP50005E (Reference Only)	NF	NF	NF	14.3.2.3.1a, 14.4.3.1	14.3.2.3.1b	14.3.2.3.1d	14.5.3.1g	NF	NF	14.5.3.2d	14.3.2.3.1c	NF	NF
SSP57003D	3.11.2.5.1, 3.11.2.5.2	3.11.2.7.1, 3.11.2.7.1.1, 3.11.2.7.1.2, 3.11.2.7.1.3	3.11.2.6.1.1, 3.11.2.6.1.2	3.11.2.1	3.11.2.2	3.11.2.3	3.11.3.1.3	3.11.3.1.7.3	3.11.3.1.7.4	3.11.3.1.7.1, 3.11.3.1.7.2	3.11.2.4	3.11.3.1.4.3	3.11.3.3.1

Compliance Matrix

Step	Crew Member	Worksite Outfitting	Free-Float Outfitting	RMS Outfitting	Work Envelope	Field of View	48 Work Volume	Mobility Aids	APFR Installation	APFR Ingress	Stability Aids	Glove Clearance	Handrail Envelope	WIF Envelope
1	EV1	C	n/a	n/a	C	Ce	Ce	C	C	C	C	C	Ce	C
2	EV1	C	n/a	n/a	C	C	C	C	C	C	C	C	C	C
3	EV1	n/a	C	n/a	n/a	C	Ce	C	n/a	n/a	n/a	C	C	n/a

Requirement Compliance Selections

AR	***Analysis Required***	***n/a***	***Not Applicable***	***NE***	***Not Evaluated***
C	***Compliant***	***NC***	***Non-Compliant***	***NF***	***Not Found***
Ce	***Compliant with Exception***				

Concluding Remarks

Handrail 3006 was granted an exception at the EVA AIT on August 5, 1997 and the exception is noted in SP-M-229 paragraph B.3.2.2.3.6.

The following violations were granted an exception at the EVA AIT on Sept 4, 2008 and the exception is noted in BOE-00006_SSP57003:

Step1, EV1:
48-inch Work Volume is Non-Compliant because the envelope is violated by S3 UMA.

Step 3, EV1:
48-inch Work Volume is Non-Compliant because the envelope is violated by the S3 structure.

The following violation was granted an exception at the EVA AIT on Sept 4, 2008 and the exception is noted in BOE-00007_SSP57003:

Step 1, EV1:
Field of View is Non-Compliant because the view is obstructed by the S3 PAS.

Appendix A: Acronyms and Abbreviations

3D	Three Dimensional
AIT	Analysis and Integration Team
AMS	Alpha Magnetic Spectrometer
APFR	Articulating Portable Foot Restraint
CAD	Computer Aided Design
CCR	Configuration Control Review
CCW	Counterclockwise
CETA	Crew and Equipment Translation Assembly
CLA	Capture Latch Assembly
CP	Camera Port
CSYS	Coordinate System
CW	Clockwise
DQA	Document Quality Assurance
EAR	EVA Analysis Report
ELC	Express Logistics Carrier
ERU	Engineering Release Unit
EV	Extravehicular Crewmember
EVA	Extravehicular Activity
EVA&CSI	Extravehicular Activity and Crew Systems Integration
EVAP	EVA Procedure
Ext	Extension
FPMU	Floating Potential Measurement Unit
HR	Handrail
ISS	International Space Station
MAGIK	Manipulator Analysis - Graphic, Interactive, Kinematic
MBS	Mobile Remote Servicer (MRS) Base System
MSER	Mechanical, Structural, Extravehicular Activity, & Robotic
MT	Mobile Transporter
NASA	National Aeronautics and Space Administration
PAS	Payload Attach System
PDS	Procedure Documentation System
PFR	Portable Foot Restraint
PGT	Pistol Grip Tool
PID	Prime Item Development
PIP	Push In Pull
PPAS	Passive Payload Attach System
Pub.	Publish
R&R	Remove & Replace
Rev.	Revision
RMS	Remote Manipulator System
SRMS	Shuttle Remote Manipulator System
SSCN	Space Station Change Notice
SSP	Space Station Program
SSRMS	Space Station Remote Manipulator System
TERA	Temporary Equipment Restraint Aid
UCCAS	Unpressurized Cargo Carrier Attach System Assy
UG	Unigraphics
UMA	Umbilical Mechanism Assembly
WIF	Worksite Interface
WSS	Workstation Stanchion